The incursion of Highly Pathogenic Avian Influenza (HPAI) into North Atlantic seabird populations: an interim report from the 15th International Seabird Group conference

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The H5N1 Highly Pathogenic Avian Influenza (HPAI) outbreak devastated populations of North Atlantic seabirds in the 2022 breeding season. Positive cases of HPAI in seabirds were previously reported in Great Skuas *Stercorarius skua* colonies in the 2021 breeding season (Banyard *et al*. 2022). During the 2022 breeding season, major outbreaks were sequentially reported in an increasing number of species and spread generally north to south across the UK and beyond. To date 15 breeding seabird species have tested positive in Scotland and over 20,500 birds have been reported dead (NatureScot, unpublished data). By September 2022, more than 2,600 Great Skuas had died: 13% of the UK population and 8% of the world population (NatureScot, unpublished data), 1,400 on Foula, Shetland alone (Camphuysen & Gear 2022). These figures are derived mostly from colony counts and will be a substantial underestimate of total mortality, not accounting for birds lost at sea or remote locations with limited reporting.

In response to this unfolding situation, a workshop was convened in August 2022, at the 15th International Seabird Group Conference in Cork, to bring together the seabird community (researchers, ringers, volunteers, site managers, non-government organisations and policy makers) and infectious disease experts to share knowledge and experiences and recommend positive future actions. This report focusses on three key considerations addressed by the workshop, and will be followed by a full open-access report on the EcoEvoRxiv repository. All six presentations can be viewed online (Gamble *et al*. 2022).

The views expressed here reflect the wider discussion expressed by the seabird community in the workshop that followed the presentations and should not be associated with any individual author.

Monitoring and surveillance

There are few surveillance schemes globally that routinely test for HPAI in wild live birds (South Africa being an exception; e.g. Abolnik *et al*. 2022). First response therefore usually arises from the passive surveillance of birds found dead via schemes generally designed to inform on disease risk to domestic poultry. The strain of HPAI currently circulating (lineage 2.3.4.4.b) is highly pathogenic to poultry and therefore in most countries is a notifiable disease. There are therefore legislative requirements on how any dead or affected birds, or samples that may contain the virus, are handled and tested as well as the laboratories in which these tests can be legally undertaken. In 2022, the high number of locations, species and individuals affected exceeded testing capacity, limiting the ability to understand the full extent of the outbreak and the population impacts on seabirds. Wider monitoring undertaken by the seabird community therefore played a crucial role in informing our understanding of the impact of this outbreak.

Going forward, key recommendations from the workshop included firstly, developing an active risk-based, strategically planned and targeted programme of disease surveillance and monitoring. This work program should establish the coverage of existing monitoring schemes and identify where enhanced monitoring is needed in addition to routes through which this extra capacity can be delivered across the annual cycle, including breeding, migration and wintering periods. Coordinated, systematic disease surveillance that provides rapid HPAI detection, as well as information required for future mitigation, is needed. This should be in conjunction with, and complimentary to, current wild bird surveillance schemes.

Secondly, coordinated and enhanced monitoring of seabird demography and mortality is required. Existing schemes which record population abundance and breeding success, such as the UK's Seabird Monitoring Programme (SMP) and Norway's Seabird Populations (SEAPOP) programme could evolve to encompass this additional requirement (SEAPOP 2022; SMP 2022). Key information on survival rates, derived from national ringing schemes, can be more challenging to collect during an outbreak, but remain a critical demographic parameter for predicting seabird population trends. However, new technologies, such as cameras and drones to record colony attendance, abundance and breeding success can provide efficiency benefits for calculating survival rates (Edney & Wood 2020; Hayes *et al*. 2021), and potentially reduce overall disturbance, in turn reducing disease spread. Understanding the scale of mortality in winter visitors is an additional challenge, but we could also draw upon existing surveys in the short term to help co-ordinate the collation of dead bird records (e.g. the Wetland Bird Survey (WeBS) and BirdTrack in the UK; BTO 2022a, 2022b). In the longer term, it is recognised that data gathering needs to be standardised nationally, and ideally be compatible with international reporting structures. The sharing of reports of sick and dead seabirds on social media was important in identifying the early stages of the outbreak and monitoring its spatial spread, including in remote areas. App-based data collection methods could be considered to facilitate this in future, thereby harnessing the valuable contribution of citizen scientists to enable even more useful data collection. This app-based data collection would ideally feed into a single information portal to ensure data are coordinated, accessible to all who need it, and compatible with international reporting structures.

Thirdly, understanding HPAI transmission within and between seabird populations will be key to establishing effective mitigation strategies. Seabird tracking data combined with epidemiological investigations can characterise year-round seabird movements and identify where mixing might occur: does population mixing due to movements between breeding colonies and non-breeding areas facilitate disease transmission? Does adult and immature dispersal between colonies facilitate transmission, particularly after HPAI-related breeding failures? Environmental monitoring for viral ribonucleic acid (RNA) viruses, either in the presence or absence of birds, can also be useful in identifying areas where exposure may occur and where the virus may be persisting in the environment.

Finally, monitoring the prevalence of disease in seemingly non-symptomatic, healthy birds can help to establish virulence and recovery rates across different species and potential asymptomatic vectors of infection. Post-infection serology can also be used to assess these factors retrospectively; while HPAI is an acute disease with death or recovery taking place within approximately one week, antibodies can persist for several months post-infection (Trampel *et al.* 2006).

Limiting virus spread

Avian influenza spreads by direct contact or exposure to body fluids and faeces, both potentially as aerosols (CDC 2022). The virus can also persist in the environment for extended periods of time and can therefore be transmitted indirectly, for example by water or food sources, footwear and clothing, or fieldworker equipment. The main aims of biosecurity measures are a) to protect individuals who may be exposed to the virus and b) to prevent human-mediated transmission of HPAI within and between sites, whether they be seabird colonies or where birds are kept domestically.

It was proposed that overall, biosecurity measures need to be proportionate and, at a minimum, ensure the health and safety of the observer. With respect to bird health and safety, measures should operate on a precautionary principle with a clear operational workflow based on risk. Risk assessments should adhere to the relevant health and safety advice in relation to a specific field site and conditions (WOAH 2022). Avian influenza biosecurity measures are currently informed by what is known about virus transmission in commercial settings. It will therefore be necessary to monitor the direct and indirect effects of biosecurity measures on the epidemiology of wild birds to allow for modification of measures as evidence develops.

There was strong agreement on the urgent need for clarity and guidance on the removal of carcasses and sick birds within infected colonies. Future decision making and operational procedures need to consider the impact of removal and the risk and timing of these interventions. Data on outcomes in both scenarios should be shared promptly to enable impacts to be more widely assessed, to further improve decision making.

An integrated approach

There are numerous pressures acting on seabird populations but to date, disease has not been widely integrated into seabird conservation strategies and other marine strategies/assessments. Doing so will enable its impact to be considered collectively and prioritised accordingly alongside other pressures on seabird populations. Continued testing will be an important component of future monitoring, both to identify or discount disease as an explanatory factor affecting key demographic components. We are, for example, potentially seeing the start of another 'auk wreck' in the UK in autumn 2022, as in autumn 2021 when no HPAI positive results were found (Fullick *et al.* 2022). We can expect HPAI to persist into the next breeding season and beyond, with unpredictable consequences. However, we cannot assume that HPAI will impact seabirds in the same manner. Maximising our knowledge of species-specific responses to infection and environmental persistence of the virus will be key to identifying appropriate mitigations.

What can seabirders do?

To empower the seabirder community – from individual birders to conservation professionals to academics – in the face of these pressing issues, we summarise some key actions for us all to aid mitigating or reducing the probability of future HPAI outbreaks. Whilst we have given UK monitoring schemes as examples, we would urge readers to check whether equivalent schemes exist for their own countries. Figure 1 shows how these actions will feed into HPAI mitigation.

1. **Engage with poultry, gamebird and wild bird communities**. Increasing awareness of symptoms and biosecurity, and reporting mechanisms for suspected cases of HPAI.
2. **Contribute to opportunistic and systematic surveillance.** For example, in the UK people should report dead birds to the Defra helpline (Defra & APHA 2022). Share information on social media if you see sick and/or dead seabirds (Twitter hashtags such as #HPAI and #seabird/#seabirds are helpful). Report any rings on dead birds but note the guidance from the British Trust for Ornithology (BTO 2022c).
3. **Support the development of mortality reporting and sharing platforms**. Volunteer to collate standardised data on mortality estimates in future outbreaks and submit to the relevant reporting scheme.
4. **Contribute to demographic monitoring**. Review monitoring plans for 2023 and beyond (e.g. Seabird Monitoring Programme, Winter Gull Roost Survey and WeBS; SMP 2022, BTO 2006; BTO 2022b) through established and new technological approaches to make efficient use of limited resources. Resurveys of colony abundance before and after HPAI will be valuable to look at demographic impacts.
5. **Collaborate with epidemiological investigations.** If you are involved in seabird colony studies, reach out to infectious disease experts: can you contribute to epidemiology studies?
6. **Lead ecological studies**. Increase our knowledge and understanding of long-term implications to seabird populations from HPAI, e.g. on migration, population age and sex dynamics, behaviour and the wider ecosystem.

7. **Implement biosecurity guidelines**. Engage with plans for biosecurity in your study. Lead by example and follow the guidelines on other threats (climate change, bycatch, forage fisheries exploitation, offshore wind development).
8. **Lead studies of other threats**. Engage in research on seabird conservation (climate change, invasive mammalian species, fisheries, bycatch, offshore wind development and pollution) to protect seabirds from other threats and help seabirds and seabirder communities build resilience to future outbreaks of HPAI and other infectious diseases.

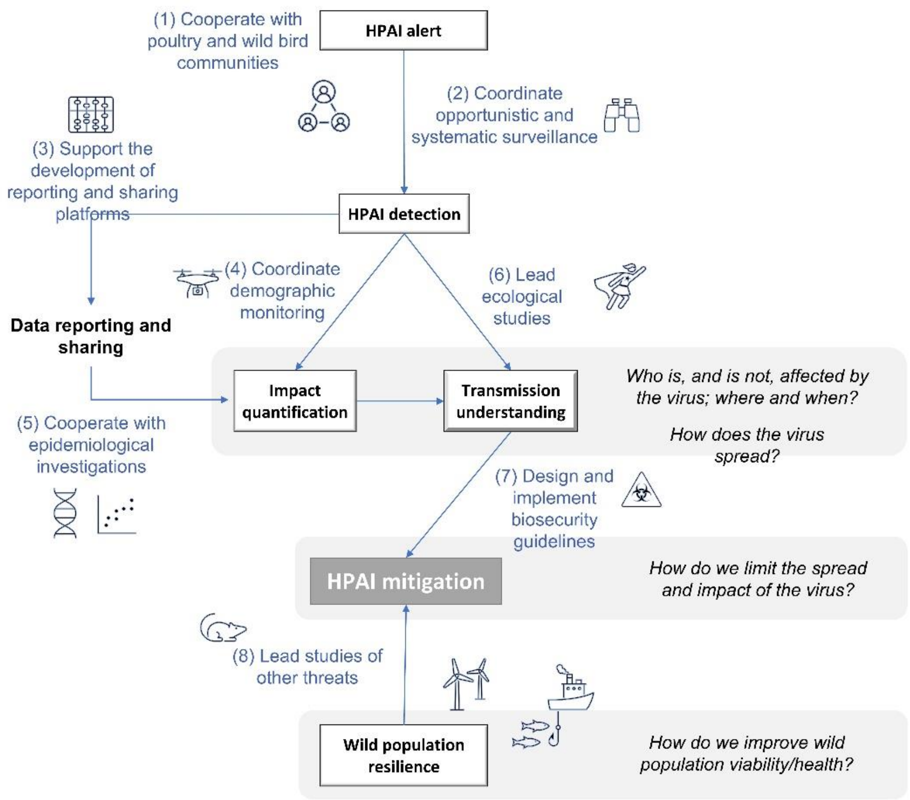

Figure 1. The role of seabirders in HPAI mitigation, from case suspicion to outbreak mitigation.
Italic text indicates outstanding questions. Blue text indicates actions that should be led by the seabird community, in collaboration with infectious disease experts. Each action should be coordinated at an international scale.

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